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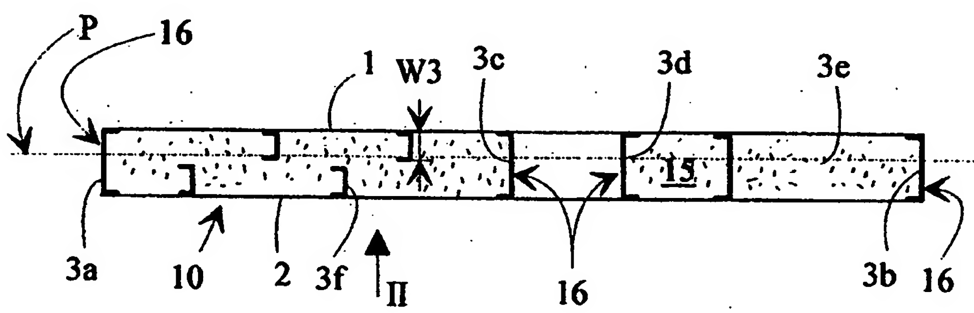

(57) Abstract

A plate-like wall structure or wall component which comprises: outer surfaces (1, 2) and, between them, loadbearing frame members made up of sheet metal profiles (3, 4), the frame members having flanges (7a, 7b) and, connecting them, a web (6) in the orientation of the thickness of the structure or the component; as well as a stiff thermally insulating composite material (15) in which the principal binding agent is a hydraulically hardening inorganic mix and which fills the spaces between the metal profiles and is bonded to these profiles. Each frame member in this wall structure or wall component consists of a thermal profile (3, 4) the web and flanges of which are made up of one bent sheet metal piece and which comprises in its web thermal perforation (9) reducing the conduction of heat. All of those side edges (16, 26) of the wall structure or wall component (10) which are transverse to the plate orientation (P) are made up of the said thermal profiles, and the thermally insulating composite material (15) is a thermal concrete the aggregate in which is in the main made up of hollow particles.

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THERMAL WALL AND METHOD FOR MANUFACTURING THE WALL

The invention relates to a plate-like wall structure or wall component which comprises: oppositely positioned outer surfaces and, between the outer surfaces, loadbearing frame members formed of thermal profiles, the frame members being made up of substantially one bent sheet metal piece and comprising: at opposite edges, flanges, at least part of one or both flanges being located in the area of the outer surfaces; connecting the flanges, a web in the orientation of the thickness of the structure of the component; in its web, thermal perforation which reduces the conduction of heat, the perforation being made up of substantially oblong thermal apertures, the oblong property of the apertures being parallel to the profile length and there being such apertures in adjacent rows in the web so that in any two adjacent rows of apertures the thermal apertures are offset relative to each other. The invention also relates to methods for the fabrication of wall structures and wall components of a corresponding type by using at least one casting form surface and by casting, between the sheet metal profiles and in contact therewith, a composite material in which the principal binding agent is a hydraulically hardening inorganic mix and which fills the spaces between the sheet metal profiles and forms a rigid thermal insulation.

FI publication 75389 describes a wall frame having vertical lightweight beams made from thin sheet and between them foamed concrete the density of which is stated to be at maximum 600 kg/m^3. The description in the publication also mentions 350 kg/m^3 as a possible density for the foamed concrete, and the figures in the publication also depict such a positioning of these light beams that no cold bridges are formed in the orientation of the thickness of the wall frame. In addition, one of the figures in the publication shows a curve purporting to depict the thermal conductivity of foamed concrete as a function of the density. In those structures according to the publication in which cold bridges are avoided, it has been necessary to use profiles having a very small cross-sectional surface, in which case the loadbearing capacity of the wall is poor. One figure in the publication depicts profiles wider relative to the wall thickness, in which case a good loadbearing capacity can be obtained for the wall with a sufficient wall thickness. Since in this embodiment the metal profiles extend directly from one outer surface of the wall to the other outer surface, there are, nevertheless, cold bridges formed in their area, and so this structure of the reference publication is not suitable for an exterior wall of a building. On the basis of practical experiments, the foamed concrete density of 350 kg/m^3 mentioned in the publication is not suitable for use in exterior walls or in loadbearing walls, since the

strength of such concrete is very low and, furthermore, it has a considerable tendency to crack. In addition, in fact the value of the thermal conductivity of such foamed concrete having a density of 350 kg/m^3 is, contrary to what is shown in the figure of the reference publication, approx. 0.1 W/m^2·K, which is not sufficient insulation for an exterior wall. On the basis of practical experiments, a non-cracking and sufficiently strong wall structure is achieved only by using foamed concrete having a density of at minimum 600 kg/m^3, and the thermal conductivity of such foamed concrete is of the order of 0.16 W/m^2·K, which, at least in Finnish conditions, is far too high a value for the thermal conductivity of an exterior wall if it is desired to keep the wall thickness moderate. On the other hand, the increasing of the wall thickness considerably increases the weight and price of the structures and is therefore not a practicable solution. Furthermore, it is to be taken into account that the manufacturing process of foamed concrete, i.e. the process of foaming the concrete mix, is technically very difficult to control, and therefore there easily tends to be formed a defective product which may have to be remade and the original may have to be destroyed or be used for secondary purposes, which further increases the price of the structure. The wall structure according to FI reference publication 75389 has thus not been used anywhere. Corresponding structures have also been described in US publications 2 762 472, 4 805 357 and 2 934 934. In these, the sheet profiles contain very large apertures and, nevertheless, there are direct routes for heat transfer from one surface of the wall to the other. The strength of such a profile is low and its thermal insulation capacity poor. The casting mix used is either air-entrained concrete, ordinary concrete, or a concrete containing perlite or vermiculite as the filler. The thermal insulation capacity of such mixes is at maximum of the same order as that of the foamed concrete described above, but usually considerably lower. Thus, a wall which both is strong and has a high thermal insulation capacity is not obtained by using these described structures.

US publication 4 918 897 describes a very complicated system for the construction of multiple story buildings. The vertical loadbearing sheet profiles in this reference publication have perforated portions which, according to the description in the publication, are intended for improving the bonding between concrete and the metal profile. The publication does not include a more detailed description of the quality or type of the concrete or corresponding mix to be cast between the sheet metal profiles, and thus what is in question is probably conventional concrete having sand and/or gravel and/or crushed stone as the aggregate. Furthermore, the sheet metal profiles according to the publication are made from a plurality of parts, and therefore their manufacturing costs are high. Thus, it is indispensable to provide a sepa-

rate insulation in a loadbearing wall structure according to US publication 4 918 897, as is indeed shown in the figures in the publication. In addition, the structure will be very heavy and, owing to the complicated character of the sheet metal profiles, also very expensive.

Publications US-4 713 921, EP-0 136 618 and SE-394 478 describe thermal profiles made from sheet metal, wherein the web of the profile has oblong longitudinal slit-like apertures, the apertures adjacently positioned in the orientation of the profile width being offset one relative to another. Thus the thermal flow from one outer surface to the other will have to travel past the slit-like apertures via a considerably tortuous route, which improves thermal insulation as compared with a profile perforated in some other fashion. However, the apertures being relatively small enables the sheet metal profile to have moderate strength. According to these publications, the thermal insulation is mineral wool in the form of panel pieces placed between the profiles. However, such a wall structure requires relatively sturdy profiles when the wall is to be made loadbearing. This increases the costs.

An object of the present invention is therefore to provide a cast-on-site wall structure or a wall component prefabricated elsewhere and brought to the building site in which structure or component the loadbearing sheet metal profiles can be made simultaneously capable of bearing high loads and to make good thermal insulation of the wall possible. This means thus that the loadbearing sheet metal profiles used withstand high loads in the direction of their length, but do not form cold bridges extending across the wall. Another object of the invention is to provide a wall structure or wall component of this type wherein the thermally insulating composite material provided between the sheet metal profiles is simultaneously light in weight, well thermally insulating, and strong. This means that extra thermal insulation is not necessarily required in a wall structure or wall component according to the invention; when necessary, the rigid thermally insulating composite material filling the spaces between the sheet metal profiles may, at a moderate thickness, form a sufficient thermal insulation for an exterior wall of a building even in Finnish conditions. Of course, this does not mean that it would not be possible to use extra thermal insulation, nevertheless. A third object of the invention is a wall structure or wall component of this type wherein all the materials and structural parts are so simple and easy to use that the manufacturing costs of a wall structure cast on site or a wall component prefabricated elsewhere and brought to the building site are low.

The above disadvantages can be eliminated and the objects defined above can be achieved by using a wall structure or wall component according to the invention, which is characterized in what is stated in the characterizing clause of Claim 1, and by the method according to the invention, which is characterized in what is stated in the characterizing clauses of Claims 7 and 8.

The most important advantage of the invention is that the new thermal profile used in it has properties which especially well prevent the conduction of heat in the direction of the wall thickness and at the same time has a very good loadbearing capacity in spite of its low thermal conductivity. Another advantage of the invention is that the density of the thermal concrete used in a wall according to the invention may be less than 350 kg/m^3 while the strength of the thermal concrete is, nevertheless, very good. Furthermore, this thermal concrete does not have any tendency to crack at this said density and not even at a lower density. In addition, the thermal conductivity of the thermal concrete to be used in the structure according to the present invention is very low, for example at the said density 200-250 kg/m^3 of the order of 0.06 W/m^2·K, and thus the thermal insulation provided by this thermal concrete is very good even at small wall thicknesses. In addition, wall structures according to the invention may be fabricated either on site or as components elsewhere by a simple and easily controlled manufacturing method in which the error possibilities are very small. Thus, by using the structure according to the invention, durable, lightweight walls with a high loadbearing capacity and a high insulation capacity are obtained for exterior walls and partition walls of buildings.

The invention is described below in greater detail, with reference to the accompanying drawings.

Figure 1 depicts a horizontal cross section of a wall structure or wall component according to Figure 2, through its plane I-I:

Figure 2 depicts, as seen in a horizontal direction, a typical wall structure or wall component according to the invention and its adjoining to the adjacent wall structure or wall component, from direction II in Figures 1 and 3.

Figure 3 depicts schematically an extension of a wall structure section or a wall component according to the invention or their connection to each other, in a horizontal cross-section through plane III-III in Figure 2.

Figures 4A-4F depict cross-sections of some embodiments of the thermal profile according to the invention, through IV-IV in Figure 2.

Figure 5 depicts one thermal perforation of a thermal profile according to the invention, in a direction perpendicular to the web of the profile. from direction V in Figures 4A-4F.

Figure 6 depicts the connection of two wall structure sections or wall components according to the invention in area VI of Figure 3, but on a larger scale and supplemented with potential additional structural parts of the wall.

Figure 7A depicts one preferred embodiment of the fabrication of a wall component according to the invention. seen from above from direction VII in Figure 7B.

Figure 7B depicts the wall component prefabrication method according to Figure 7A, as seen in a horizontal direction as a cross-section through VIII-VIII in Figure 7A.

Figure 8A depicts one method according to the invention for the fabrication of a wall structure, a wall structure section or a wall component by another method according to the invention, as seen from above from direction IX in Figure 8B.

Figure 8B depicts the method according to Figure 8A for the fabrication of a wall structure, a wall structure section or a wall component, as seen from the side in a cross-section through X-X in Figure 8A.

In the following description, reference numeral 10 is used for indicating in general a wall structure, wall structure section or wall component according to the invention. Reference numerals 10a and 10b are used for indicating a wall structure section or a wall component only when the case is of two adjoining or otherwise separate wall structure sections or wall components. Reference numerals 3 and 4 are used for indicating generally sheet metal profiles, and specifically thermal profiles according to the invention. when it is not necessary to define their location or position. Their modified reference numerals 3a, 3b, 3c, etc., and, respectively, 4a, 4b, 4c, etc., are used only when it is necessary to specify the location or position of a thermal profile according to the invention. Reference numeral 5 is used for the thermally insulating composite material when it is in a fluid, i.e. castable, form and reference numeral 15 when it has hardened to its final loadbearing and thermally insulating form. It is to

be understood that in this case sometimes both reference numerals are needed for defining the composite material. The wall structure, wall structure section, or wall component according to the invention has, of course, a plate orientation P, which denotes a plane parallel to the oppositely positioned outer surfaces 1 and 2 of the wall structure or wall component, the plane being indicated as plane P in Figures 1 and 3, the wall structure or wall component according to Figure 2 being seen perpendicular to it. By oppositely positioned outer surfaces 1 and 2 is meant here the two outer surfaces of the wall structure or wall component, formed after the fabrication method according to the invention, which surfaces are, of course, not necessarily the same surfaces as the exterior surface of the final wall and the surface facing the interior of the building, these surfaces being clarified by means of Figure 6.

These plate-like wall structures or wall components have, between their outer surfaces 1 and 2, loadbearing frame members made up of sheet metal profiles 3, 4, which frame members are thus in the final building either vertical, as are the frame members 3a-3f in Figure 2, or in an oblique position, as are the frame members 3g in Figure 7A. These frame members have each, at their oppositely positioned edges flanges 7a and 7b, a web 6 connecting the flanges and extending in the orientation of the thickness D of the structure or component. In this case at least a portion of one flange 7a or 7b, or a portion of each of the flanges 7a and 7b, or one flange 7a or 7b entirely, or both flanges 7a and 7b entirely are located within the area of the above-mentioned outer surfaces 1 and 2 or in alignment with them. Furthermore, the plate-like wall structure, wall structure section or wall component in its final form of use comprises a stiff thermally insulating composite material 15, which fills the spaces between the sheet metal profiles and is bonded to these profiles. It is to be pointed out specifically that such a stiff thermally insulating material 15 is a material the principal binder in which is a hydraulically hardening inorganic mix, such as cement, in which case it is possible to use Portland cement, blast furnace slag, mixtures thereof, or other as such commonly known or new materials, called for example cements, or mixtures thereof, according to the requirements of the targeted use in each given case.

The wall structure, wall structure section or prefabricated wall component 10 according to the invention comprises frame members 3a, 3b, 3c, etc., 4a, 4b, etc., which consist of the thermal profile 3,4 according to the invention, the web 6 and flanges 7a and 7b of the frame members being made up of substantially one bent sheet metal piece, as can be understood especially on the basis of Figures 4A-4F. These thermal profiles 3, 4 comprise in their webs 6 thermal perforation 9 which re-

duces the conduction of heat from the direction of one flange 7a towards the other flange 7b, and of course also in the opposite direction. By thermal perforation 9 is meant the region of thermal apertures 11 located over a certain width of the web, which area is in the thickness direction D of the wall and extends over the entire length LL of the thermal profile. All of the side edges 16 and 26 of the said wall structure or wall component 10, transverse to its plate orientation P, i.e. parallel to the wall thickness D, are made up of said thermal profiles 3,4. This means that the vertical and horizontal free side edges 16 of the wall structure or wall component, as well as the side edges 26 of, for example, the window openings, the door openings or any other openings 25 are made up of the said thermal profiles 3, 4. In this case, also, no cold bridges are formed in the orientation of the wall thickness D in the area of the side edges 16, 26 of the wall structure, its section or the wall component. In this connection it can be pointed out that the thermal apertures 11 in these thermal profiles 3, 4 in the edges 16, 26 need not be of the same size as the thermal apertures 11 in the thermal profiles 3, 4 within the structure in the area of the outermost side edges 16, 26. One further characteristic of the invention is that the thermally insulating composite material 15 is a thermal concrete the aggregate of which is in the main made up of hollow particles. These hollow particles make it possible that the thermal insulation capacity of the thermal concrete is high, its volume weight is low and, nevertheless, its strength is high. The wall structure or wall component according to the invention is thus based on a combination in which, first, all the metal frame members both in the side edges 16, 26 of the structure and within the structure are made up of thermal profiles 3, 4, and second, the spaces between these frame members are filled by a substantially thermally insulating composite material. The composite material is thus a thermal concrete in which the aggregate consists mainly of hollow particles.

The structure and structural alternatives of the thermal profile 3, 4 according to the invention are shown in greater detail in Figures 4A-4F and in Figure 5. The thermal profile may, first, be in cross-section a U-profile, as shown in Figures 4A-4D. In these, the flanges 7a and 7b of the profile are typically perpendicular to the plane of the web 6 or to the mean plane, as shown in the figures. Figures 4E and 4F show that embodiment of the thermal profile 3, 4 in which the extreme edges of the profile flanges 7a and 7b have edge folds 8 pointing against each other, in which case the thermal profile is in its cross section a so-called C-profile. It is, of course, clear that there may also be an edge fold 8 at the extreme edge of only one flange 7a or 7b, an embodiment not shown in the figures. Figures 4A and 4E show a thermal profile according to the invention in which the web 6 is straight and contains only

the area 9 of the thermal perforation. Figures 4B and 4D show thermal profile embodiments in which the web 6 contains two sets of stiffener folds 13 parallel to the profile length LL, the folds being oriented in the same direction from the web as are the flanges 7a and 7b. Figure 4F shows an embodiment in which one stiffener fold 14 is oriented from the web 6 in a direction opposite to the orientation of the flanges 7a and 7b. When this thermal profile 3, 4 of the type shown in Figure 4F is used, care must be taken during the assembling of the side edges 16 of the wall structure, its section or the prefabricated wall component that the profiles will come in the correct orientation so that the stiffener grooves 13 and stiffener projections 14 of the adjoining wall structure sections or wall components 10a and 10b will in the final installation settle in correct positions relative to each other. These stiffener folds 13, 14 may additionally be used for holding in place the insulation between adjoining wall structure sections or wall components, as will be described below. The cross-sectional shape of the stiffener folds 13, 14 may be any selected shape. The figures show triangular and semicircular shapes, but it would also be possible to use a rectangular or other shape. If the web of a thermal profile has two stiffener folds, it is usually advantageous to provide thermal perforation 9 only between these stiffener folds and to place the folds rather close to the flanges 7a, 7b.

It should also be taken into account that the distance W3 between the outer surfaces of the flanges 7a, 7b of the thermal profiles intended for the side edges 16, 26 of the wall structure or wall element must be equal to the thickness D of the desired structure or component to be cast from thermal concrete, as can be understood on the basis of Figures 1, 3 and 6, as well as 7B and 8A. The thermal profiles for the central parts of the wall structure or wall component, such as thermal profiles 3f in Figures 1 and 2, may have a width W3 smaller than the thickness D of the wall structure or the wall component or the thermal concrete.

The thermal perforation 9 of the thermal profile 3,4 according to the invention is made up of oblong thermal apertures 11, the length L1 of the thermal apertures being parallel to the profile length LL. The web 6 has such thermal apertures in its width orientation W3 in several adjacent rows 12a, 12b, 12c, etc., as can be seen in Figure 5, which shows in part the webs of profiles according to Figures 4A-4F. Typically the length L1 of the thermal apertures 11 is at least five times, preferably at least ten times, and possibly even 25 times the width W1 of the apertures. In practice the web has thermal apertures 11 in at least three adjacent rows 12a, 12b and 12c, as shown in Figures 7B and 8A, but most preferably the number of rows of these thermal apertures is greater, for example four or six, as shown in Figure 5. In

addition, in any two adjacent rows of apertures, such as rows 12a and 12b, respectively rows 12b and 12c, as well as rows 12c and 12d, the thermal apertures are offset relative to each other. This means that in one row the distance L2 between successive thermal apertures 11 is in alignment with the length L1 of a thermal aperture in the adjacent row of thermal apertures 11, and typically in the middle of this length L1, as is shown in Figure 5. The distance W2 between the adjacent rows 12a, 12b, 12c, etc., of thermal apertures is typically greater than the thermal aperture width W1 in the direction of the width W3 of the web. However, these width dimensions are in each given case designed keeping in mind the required loadbearing capacity and thermal insulation capacity.

As was pointed out above, the binder in the thermal concrete 15 is made up of a hydraulically, i.e. by means of water, hardening, at least in the main inorganic mix, such as any known cement type or new cement type or a corresponding material. The mix may also contain organic additives. These mixes and any additives are all materials known per se, and therefore they are not described here in greater detail. In addition, the particles of the filler or aggregate of the thermal concrete 15 consist at least in the main of hollow microspheres having an outer diameter in any case smaller than 3 mm and in practice at maximum 2 mm. The structure of a thermal concrete consisting of larger microspheres is often non-homogeneous and too brittle. The hollow microspheres of the aggregate of thermal concrete according to the invention have an outer diameter preferably at maximum 1 mm, but it is also possible to use microspheres of an order of 0.5 mm. The material of these hollow microspheres may be any glass type or any ceramic material or any suitable plastic. The aggregate of the thermal concrete may also consist of a mixture of hollow microspheres of different materials. Such hollow microspheres are known per se, and they are used as aggregates or fillers in different materials, and thus it is not necessary to describe them here in greater detail. The density of a thermal concrete 15 of the type described above, i.e. a hardened and dried thermally insulating composite material, is according to the invention less than 350 kg/m^3, and preferably less than 300 kg/m^3. Typically the thermal concrete used in a wall structure or wall component according to the invention is a thermal concrete which contains the binder and aggregate described above and has a density within a range of 200-250 kg/m^3. Thus there is easily reached a thermal insulation capacity which is below 0.06 W/m^2·K with reasonable and normally used wall thicknesses. If what is in question is a wall in which great strength is not required it is also possible to use a thermal concrete having a density of the order of 150 kg/m^3. Even at this density, a thermal concrete of the type described will not tend to crack but is stable in structure, contrary to

foamed concretes. Since the thermal concrete used has a hardening mechanism of the same type as other conventional concrete mixes, there are no production problems in the casting and hardening of the concrete mix 5. It is, of course, possible to use in the aggregate not only the hollow microspheres described above but also aggregate particles of other types, but usually these are of no advantage; sufficient strength and a high thermal insulation capacity are achieved by using the hollow microspheres described above or a combination of hollow microspheres of different materials and/or of different sizes.

As was already described above, it is possible to use in a wall structure or in wall components according to the invention thermal profiles 3, 4 which have in their thermal perforation 9 either the same or different size of thermal apertures 11. When the fabrication method, described below, according to Figures 7A and 7B is used, the size of the thermal apertures 11 may be equal in all of the thermal profiles 3, 4. In this case the smallest dimension W1 of the thermal apertures must be smaller than the smallest outer dimension of the hollow particles of the thermal concrete 5. Thus, the thermal profiles 3,4 forming the outermost side edges 16, 26 of the wall structure or wall component will not allow a fluid castable composite material 5 through but the material will remain within the area delimited by the frame members 3a, 3b, 3c, 3d, 4a, 4b forming the edges in the case of Figure 2 and within the area delimited by frame members 3a, 3b, 4a, 4b in the case of Figure 7A. Thus the thermal concrete mix 5 is to be distributed over the entire area of the wall structure or wall component in case all of the thermal profiles of the structure are of a type the width W3 of which is equal to the wall thickness D. If, on the other hand, thermal profiles 3, 4 having a width W3 smaller than the wall thickness D, such as profiles 3f according to Figures 1 and 2, are used inside the outermost side edges 16, 26, the fluid thermal concrete mix 5 will flow without hindrance, even when poured at one point, over the entire area of the wall structure or wall component. If, on the other hand, it is desired to cast the fluid thermal concrete mix 5 from only one point and simultaneously to use inside the outermost side edges 16, 26 thermal profiles 3, 4 extending in their width W3 over the entire wall thickness D, in this case the smallest cross-sectional surface W1 of the thermal apertures 11 in the thermal profiles, such as profiles 3e, in the middle of the structure must be substantially greater than the greatest outer diameter of the hollow particles of the thermal concrete 5, in which case the fluid thermal concrete mix 5 can flow through the thermal apertures 11 of the thermal profiles over the entire surface area of the wall structure or wall component. To summarize, it can thus be noted that if it is desired to perform the casting into a wall structure or wall component from only one point, the thermal profiles

other than those forming the outermost side edges 16 and 26 must be either profiles having a width W3 smaller than the wall thickness D or profiles in which the smallest width W1 of the thermal apertures 11 is substantially smaller than the maximum outer diameter of the hollow particles of the thermal concrete. If it is possible to cast the fluid composite material 5 from several points to all possible spaces of the structure, the above limitations are, of course, not necessary. In any case, according to the invention the thermal profiles 3, 4 forming the outermost side edges 16 and 26 must be of a type in which the smallest width W1 of the thermal apertures 11 is substantially smaller than the smallest outer diameter of the hollow particles of the thermal concrete.

When wall structure sections or wall components 10a and 10b according to the invention are attached one as a continuation of another, a joint structure 30 according to the invention is used; it is shown schematically in Figure 3 and one preferred embodiment of it is shown in greater detail in Figure 6. This joint structure 30 comprises, first, in the orientation of the thickness D of the structure sections or wall components, a sealing strip 31 at least between the side edges 16 of adjacent structure sections or components 10a and 10b, the sealing strip extending in the orientation of the thickness D at least across the area of the thermal perforation 9 of the thermal profiles. This thus means that the sealing strip 31 covers the thermal apertures 11 of both of the thermal profiles 3, 4 coming against each other. In addition, in the embodiment of Figure 6, the stiffener grooves 13 of the thermal profiles coming against each other are used for keeping the sealing strip 31 in place. This additional function is effected, for example, so that the sealing strip 31 has a widening 37 corresponding to the grooves 13, this widening preventing the sealing strip 31 from moving in the direction of the thickness D. Furthermore, in the area of the other stiffener folds 13 coming against each other there is a guide strip 33, which locks the adjacent wall structure sections or wall components 10a and 10b into alignment. This locking into alignment may, of course, also be effected under the mutual action of an outwardly oriented stiffener fold 14 and a stiffener fold 13 oriented towards the flanges; this combination is not shown in the figures, but it can be understood on the basis of Figure 4F. As can be seen from Figures 4A-4F, the stiffener folds 13, 14 may have a desired cross-sectional shape, usually notch-like and in this case either curved or angular.

In Figure 6, the warm side of the wall structure is indicated by (+), and this outer surface 2, towards the interior of the building, of a wall structure or wall component is in this case clad with a gypsum board 35. The other outer surface 1 of the wall

structure or wall component according to the invention is surface treated first with an attenuating bonding agent 32 and, on top of this, a thermal insulation board 34. On top of the latter there is a rendering coat 36 reinforced with a metal or plastic netting. This side, coming on the cold side of the wall is indicated by (-). It is clear that any other suitable or desired surface treatment may be used instead of the boards on either one of the outer surfaces 1 and/or 2.

The plate-like wall component 10 according to the invention can be fabricated either by the method depicted in Figures 7A-7B or by the method depicted in Figures 8A-8B, although the method depicted in Figures 7A and 7B is, according to the current conception, often preferable, especially in the prefabrication of wall components. On the other hand, by the method depicted in Figures 8A and 8B it is possible to fabricate advantageously, on site in its final position, a plate-like wall structure according to the invention, or a section thereof. In either case, there is first arranged one casting form surface 20, corresponding to the plate orientation P or parallel to the planarity P of the component and having the size of at least one outer surface 1 or 2 of the component, the form surface being typically made up of one surface 20 of a suitable form piece 22. Next, at least loadbearing frame members 3a, 3b, 3c, etc., are placed against this casting form surface 20, and, when necessary, frame members 4a, 4b, etc., the frame members being made up of thermal profiles 3, 4 according to the invention. At least one flange 7a or 7b of each of these thermal profiles 3, 4 is placed against this casting form surface 20, whereupon the webs 6 of thermal profiles 3, 4 will be at least in the main in the orientation of the intended wall thickness D.

Figures 7A and 7B depict one preferred method according to the invention for the fabrication of a plate-like wall component. In this case, only one casting form surface 20, mentioned above, is used. A sheet metal profile 3a...3d, etc., and 4a...4d, etc., corresponding to and forming each free side edge 16 and 26 of the component is placed against this casting form surface 20 in such a manner that one flange of each of these profiles, either flange 7a or, according to the figure, flange 7b, settles against this casting form surface 20. Thereafter, care is taken that the casting form surface 20 is substantially horizontal, regardless of the position, described above, of the casting form surface at the placement step of the sheet metal profiles 3,4. When the casting form surface 20 is horizontal, the webs 6 of the thermal profiles 3, 4 are substantially vertical. Besides the said thermal profiles at the side edges 16, 26, it is possible to place, within the area delimited by the side edges 16, 26, in any manner described above thermal profiles 3, 4 of any type described above, for example

thermal profiles 3f and/or 3e and/or 3g. Thereafter the fluid composite material 5 forming the thermal insulation is cast between the sheet metal profiles 3a-3d, 4a-4d situated at the free edges 16, 26 of the plate-like wall component 10 in the case of the structure of Figure 2, or between the sheet metal profiles 3a-3b and 4a-4b in the case of the structure of Figure 7A. This casting depicted in Figures 7A and 7B is carried out either at one point or at several points of the area delimited by the thermal profiles 3, 4 at the side edges 16, 26, depending on the types of the intermediate profiles 3e, 3f and 3g and on the fluidity of the fluid thermal insulation material 5. Thereafter, the thermally insulating composite material 5 is allowed to harden, whereupon a stiff thermal insulation material is formed. This cast and hardened composite material 15, of course, is bonded to the thermal profiles 3, 4, in particular under the effect of the thermal apertures 11 in them. This casting form surface 20 has the size of at least one outer surface 1 or 2 of the component to be cast, but it may be even clearly larger, as can be understood on the basis of Figure 7A. The fluid thermal insulation material 5 is in this case cast so that the upper level, not indicated in the figures, of the fluid material 5 settles at maximum at the level 2 of the upwardly oriented flanges 7a of the sheet metal profiles at the side edges 16, 26 of the component. In this case, after the thermal insulation material has hardened to a thermally insulating composite material 15, the upper surface of this material is at the same level as the flanges 7a of the thermal profiles 3,4, whereby the other outer surface 2 of the component is formed. It must, of course, be taken into account that if the fluid thermal insulation material shrinks upon hardening, it is sensible to cast it to a slightly higher level, whereupon the upper surface of the hardened thermally insulating composite material 15 will be at the same level as the flanges 7a, forming the second surface 2 of the component. In this manner two smooth surfaces 1 and 2 are obtained for the wall component 10, one by means of the casting form surface 20 and the other by means of an open upper part freely settled at a level. After the fluid thermal insulation material 5 according to the invention has hardened to a stiff and strong composite thermal insulation material 15, the casting form surface 20 is detached from the formed wall component 10. The wall component can then be transported or transferred to the installation site. One and the same casting form surface 20 can then be used for casting more new components. Thus the casting form surface is a normal form surface which adheres as little as possible to the thermal insulation material 5, 15 cast.

It is, of course, understandable that in the fabrication method described above it is also possible to cast in layers different hardening composite materials in order to obtain the desired properties in the product. The casting of the upper surface may

also be left lower than the upwardly oriented flanges 7a, in which case the remainder of the wall thickness D can be used for some other purpose or be filled with some other material. It is also most expedient to keep the casting form surface 20 horizontal also during the placing step of the frame members and all other thermal profiles 3, 4, in which case it is not necessary to move the form plate 22 forming the casting form surface 22. In this embodiment. thermal profiles are placed in all of the free side edges 16, 26. The casting form surface 20 is preferably of a type which will not adhere, at least not firmly, to any of the materials cast, so that the casting form surface 20 can be detached easily and reliably after the hardening of the castings. It is, of course, possible to use a mix which tends to adhere to the form surface, as long as there is, between this mix and the casting form surface, a layer of a material, such as the hardening thermal insulation material 5 according to the invention, which will not adhere to the casting form surface 20. In this case, however, it is necessary to observe sufficient caution so that there will be no difficulties encountered in the detaching of the casting form surface.

The embodiment of Figures 8A and 8B can also be used for prefabricating wall components, but typically it is used for fabricating a wall structure or a section thereof on site. In this embodiment it is not necessary to install any thermal profile 4a at the lower edge, although the profile is preferable in terms of the strength and rigidity of the structure. Likewise, the thermal profile 4b for the upper edge of the structure may be installed either before the casting of the fluid thermal insulation material 5 or only after its casting but before its hardening. In all other respects the frame members 3a, 3b. 3c, etc., 4c, 4d, etc., and the other thermal profiles 3, 4, are placed against one casting form surface 20 in such a manner that one flange of each thermal profile, such as flange 7b, will settle against this surface and the webs 6 of the profiles will be perpendicular to this surface 20. As above, this casting form surface 20 is also made up of a form piece 22. In this case, also, the casting mold surface 20 must be in size at least equal to an outer surface 1 or 2 of the wall structure, or a section thereof, being fabricated. as can be seen in Figures 8A and 8B. At least during the casting of thermal concrete, the sheet metal profiles 3 intended for the vertical side edges 16. 26, are to be positioned so that a flange 7a or 7b of each of these profiles comes against this casting form surface. If the wall structure or its section 10 has openings 25, all of the side edges 26 of these openings are, of course, to be formed from thermal profiles 3, 4, as in the embodiment described above. When all of the necessary thermal profiles 3, 4 have been placed within the area of the wall structure or its section 10, there is placed against at least the flanges 7b, or respectively 7a, of the thermal profiles 3, 4 in the side edges 16, 26, oriented away

from the first casting form surface 20 a second vertical casting form surface 21, which may in the conventional manner be made up of one surface of a plate or other form material 23, as can be seen in Figure 8A.

Figures 8A and 8B depict the situation in which the upwardly facing side edge 16 has a special-type thermal profile 4b, which contains sufficiently large gates 19 for the casting of a fluid and hardening composite material 5. Figures 8A and 8B thus depict a casting situation in which there are, pressed between two casting form surfaces 20 and 21, thermal profiles 3, 4, which form both upright frame members 3a, 3b, etc., and a lower edge frame member 4a and an upper edge frame member 4b, in which case all the thermal profiles except the upper edge profile 4b are of the ordinary type depicted in Figures 4A-4F and 5, having in their webs only thermal apertures of the size described above, whereas the thermal profile 4b of the upper edge additionally contains casting gates 19 or at least one casting gate. The flanges 7a and 7b of at least the thermal frame members at the edges 16, 26 are pressed against the casting form surfaces 20, 21, whereby a casting form tight at its edges is produced for the fluid composite material 5. For the casting of thermal concrete, the casting form surfaces are arranged to be vertical or nearly vertical, although the placing of the thermal profiles can be carried out in any position suitable in the given case. Thereafter the fluid thermal insulation material 5 is cast, for example, through the gates 19 shown in Figures 8A and 8B, until the volume of the wall structure, or a section thereof, delimited by the thermal profiles at the edges 16, 26, has been filled with a thermal concrete mix of the type described above. Thereafter this thermally insulating composite material 5 is allowed to harden to a thermally insulating thermal concrete 15. In this case the other alternative is to leave the thermal profile 4b of the upper edge first uninstalled, to cast first the thermal insulation material 5 via the free upper edge, and thereafter to fit a thermal profile 4b of the conventional type, i.e. without gates 19, at the correct point of the wall structure or its section before the composite material 5 hardens to thermal concrete 15. After the fluid thermal insulation material 5 according to the invention has hardened to a stiff and strong composite thermal insulation material 15, the casting form surfaces 20 and 21 are detached from the formed wall component, wall structure or its section 10. A wall structure or its section thus remains on this casting and installation site, whereas a prefabricated component can be transported elsewhere. The same casting form surfaces 20 and 21 can thereafter be used for casting more new components. Thus, both of the casting form surfaces are normal form surfaces having as minimal as possible adhesion to the cast thermal insulation material 5, 15.

Before the casting of the fluid composite material 5, i.e. during the installation of the frame members made up of thermal profiles 3, 4 on the casting form surface, it is most expedient to fasten any intersecting profiles in some suitable manner, for example, self-tapping screws or pop rivets 29 or in some other suitable manner. This will prevent any unintended shifting of the thermal profiles 3, 4 during the casting of the composite material 5. In particular in the case of Figures 7A and 7B it is advisable to fasten one to another all of the thermal profiles at the side edges 16, 26. Also thermal profiles other than those at the side edges can be fastened either one to another or to thermal profiles at the edges. In the embodiment of Figures 8A and 8B, the compression between the casting form surfaces 21 and 20 will hold the profiles in place, but even in this case it may be advantageous to use fastening 29 in order to ensure precision of the final dimensions and the strength.

Claims

1. A plate-like wall structure or wall component which comprises:

- oppositely positioned outer surfaces (1, 2);
- between the outer surfaces, loadbearing frame members (3a, 3b, 3c ...) made up of thermal profiles (3, 4), each of them consisting of substantially one bent sheet metal piece and comprising:
  - at opposite edges, flanges (7a, 7b), at least part of one or of both flanges being located in the area of the outer surfaces;
  - connecting the flanges, a web (6) in the orientation of the thickness of the structure or the component;
  - in its web, thermal perforation (9) which reduces the conduction of heat, the perforation being made up of substantially oblong thermal apertures (11), the oblong property (L1) of the apertures being parallel to the profile length (LL) and there being such apertures in adjacent rows (12a, 12b, 12c ...) in the web (6) so that in any two adjacent rows of apertures (12a and 12b; 12b and 12c; 12c and 12d ...) the thermal apertures (11) are offset relative to each other,

characterized in that, additionally:

- in the said wall structure or wall component (10), all of the side edges (16, 26) transverse to the plate orientation (P) are made up of said thermal profiles; and
- the wall structure or wall component comprises a stiff thermally insulating composite material (15) in which the principal binding agent is a hydraulically hardening inorganic mix and the aggregate is in the main made up of hollow particles and which fills the spaces between the sheet metal profiles and is bonded to these profiles.

2. A wall structure or wall component according to Claim 1, **characterized** in that the length (L1) of the thermal apertures (11) is at least five times, and preferably at least ten times, and typically approx. 25 times, the width (W1) of the apertures, that the distance (W2) between adjacent rows (12a, 12b, 12c, etc,) of thermal apertures is typically greater than the width (W1) of the thermal apertures in the orientation of the web width (W3), and that the thermal apertures (11) are in the middle region of the web.

3. A wall structure or wall component according to Claim 1 or 2, **characterized** in that the thermal profile (3, 4) is in its cross-section a U-profile, or alternatively the extreme edges of the profile flanges (7a and/or 7b) have edge folds (8) pointed towards each other, in which case the thermal profile is in its cross-section a

C-profile, and that the thermal profile has longitudinal stiffener folds (13, 14) in the web (6) between the thermal perforation (9) and at least one flange (7a or 7b), and that, when necessary, the thermal profile (4b) located at the top side edge of the wall structure or wall component has gates (19) suited for the casting of thermal concrete (5).

4. A wall structure or wall component according to Claim 1, **characterized** in that the particles of the aggregate of the thermal concrete (15) are made up of microspheres having an outer diameter of at maximum 2 mm and preferably at maximum 1 mm, and that these microspheres are of glass and/or a ceramic material and/or plastic, and that the density of the thermal concrete (15) is below approx. 350 kg/m^3, preferably below 300 kg/m^3, and typically within a range of 200-250 kg/m^3.

5. A wall structure or wall component according to Claim 1 or 4, **characterized** in that the joint structure (30) between wall structure sections or wall components (10a and 10b) to be continuations of one another in the wall comprises a sealing strip (31) extending, in the thickness orientation (D) of the wall structure sections and/or wall components, at least over the thermal perforation area (19) of the thermal profile at the said side edge (16), and that the thermal profiles have longitudinal grooves (13) and/or ridges (14) or the like for holding the sealing strip in place.

6. A wall structure or wall component according to Claim 1, **characterized** in that the said outer surfaces (1, 2) are surface treated (32) or clad with a plate material (34; 35).

7. A method for fabricating a plate-like wall component, which method comprises as its steps:

{1} there is provided at least one casting surface corresponding to the plate orientation (P) of the wall component (10) and having the size of at least one outer surface (1 or 2) of the component;

{2} there are placed between the future outer surfaces (1 and 2) of the wall component at least loadbearing frame members (3a, 3b, 3c ...), these profiles being each made up of substantially one bent sheet metal piece and having, at oppositely positioned edges, flanges (7a and 7b) and a perforated web (6) connecting the flanges in the orientation of the wall thickness (D);

{3} there is cast between the sheet metal profiles and into contact with them a composite material (5) the principal binding agent in which is a hydraulically hardening inorganic mix, and which fills the spaces between the sheet metal profiles and forms a stiff thermal insulation (15),

characterized in that in the method:

{4} the casting surface used is a form surface (20);

{5} the said sheet metal profiles used are thermal profiles (3, 4), each profile comprising in its web thermal perforation (9) reducing the conduction of heat, which perforation is made up of substantially oblong thermal apertures (11), the oblong property (L1) of the apertures being parallel to the profile length (LL) and there being such apertures in the web (6) in adjacent rows (12a, 12b, 12c ...) in such a manner that in any two adjacent rows (12a and 12b; 12b and 12c; 12c and 12d ...) of apertures the thermal apertures (11) are offset in relation to each other;

{6} at the placement step of the frame members there is positioned at each free side edge (16, 26) of the plate-like wall component a thermal profile (3a...3d, etc., 4a...4d, etc.) of the said type, in such a manner that a flange (7a or 7b) of each of these profiles settles against the said one casting form surface (20);

{7} before the casting step of the composite thermal insulation material (5), the casting form surface (20) is arranged to be substantially horizontal, whereupon the webs (6) of the thermal profiles will be vertical;

{8} the fluid composite thermal insulation material (5), in which the aggregate is in the main made up of hollow particles, is cast between the said thermal profiles (3a-d, 4a-b) at the free side edges of the plate-like wall component;

{9} the thermally insulating composite material (5 $\rightarrow$ 15) is allowed to harden; and

{10} the said form surface (20) is detached from the component (10) formed by the sheet metal profiles and the stiff thermal insulation (15).

8. A method for fabricating a plate-like wall structure or a section thereof, which method comprises as its steps:

{1} there is provided at least one vertical casting surface (20) corresponding to the plate orientation (P) of the wall structure or its section (10) and having the size of one outer surface (1 or 2) of the wall structure;

{2} there are placed between the future outer surfaces (1 and 2) of the wall structure or its section at least loadbearing frame members (3a, 3b, 3c ...), these profiles being each made up of substantially one bent sheet metal piece and having, at oppositely positioned edges, flanges (7a and 7b) and a perforated web (6) connecting the flanges in the orientation of the wall thickness (D);

{3} there is cast between the sheet metal profiles and into contact with them a composite material (5) the principal binding agent in which is a hydraulically hardening inorganic mix, and which fills the spaces between the sheet metal profiles and forms a stiff thermal insulation (15),

characterized in that in the method:

{4} the casting surface used is a form surface (20);

{5} the said sheet metal profiles used are thermal profiles (3, 4), each profile comprising in its web thermal perforation (9) reducing the conduction of heat, which perforation is made up of substantially oblong thermal apertures (11), the oblong property (L1) of the apertures being parallel to the profile length (LL) and there being such apertures in the web in adjacent rows (12a, 12b, 12c ...) in such a manner that in any two adjacent rows (12a and 12b; 12b and 12c; 12c and 12d ...) of apertures the thermal apertures (11) are offset in relation to each other;

{6} at the placement step of the frame members, at least at the future vertical side edges (16, 26) of the plate-like wall structure or its section there are positioned thermal profiles (3a...3d, etc.) of the said types so that a flange (7a or 7b) of each of these profiles settles against the said one form surface (20);

{7} before the casting step of the composite thermal insulation material (5), a second vertical casting form surface (21) is placed against those flanges (7b or resp. 7a) of the thermal profiles (3, 4) which are oriented away from the said one form surface (20), at least at the side edges;

{8} the fluid composite thermal insulation material (5), in which the aggregate is in the main made up of hollow particles, is cast into the spaces between the thermal profiles (3a...3d, etc.) at the vertical side edges of the plate-like wall structure or its section and the two casting form surfaces (20 and 21);

{9} the thermally insulating composite material (5 $\rightarrow$ 15) is allowed to harden; and

{10} the said form surfaces (20, 21) are detached from the wall structure or its section (10) made up of the sheet metal profiles and the stiff thermal insulation (15).

9. A method according to Claim 7 or 8, **characterized** in that in the method, at the placement step {4} of the frame members, all of the side edges (16) and additionally the side edges (26) of the necessary window openings, door openings and/or any other openings (25) are formed in the building component by using the said thermal profiles, which thermal profiles (3, 4) placed at the edges are fastened one to another at their meeting points.

10. A method according to Claim 7 or 8, **characterized** in that in the method, additionally, at the placement step {4} of the frame members other frame members (3e, 3f, 3g, etc.) are placed within the area delimited by the thermal profiles placed at the outermost side edges (16), these other frame members being preferably of the same profile type as the said thermal profiles placed at the side edges, and that the thermal apertures (11) are within the middle region of the web.

11. A method according to Claim 7, **characterized** in that in the method, additionally, the form surface (20) is kept in a horizontal position throughout the placement step {4} of the frame members, and that at the casting step {6} of the thermal insulation material the casting is done at maximum to the level (2) of the upwardly oriented flanges (7b) of the thermal profiles, at least at the side edges (16, 26).

12. A method according to Claim 8, **characterized** in that in the method, additionally, either:

- at the placement step {4} of the frame members there is positioned at the upper edge of the wall structure or its section a sheet metal profile (4b) which has gates (19) for the casting of a fluid thermal insulation material; or
- after the casting of the fluid thermal insulation material (5), a sheet metal profile (4b) is positioned at the upper edge of the wall structure or its section.

13. A method according to Claim 7 or 8, **characterized** in that the aggregate in the castably fluid and hardening thermal insulation material ($5 \rightarrow 15$) consists, at least in the main, of hollow particles and that the particles are microspheres which are made up of glass or a ceramic material or plastic, whereby a thermally insulating thermal concrete (15) is formed.

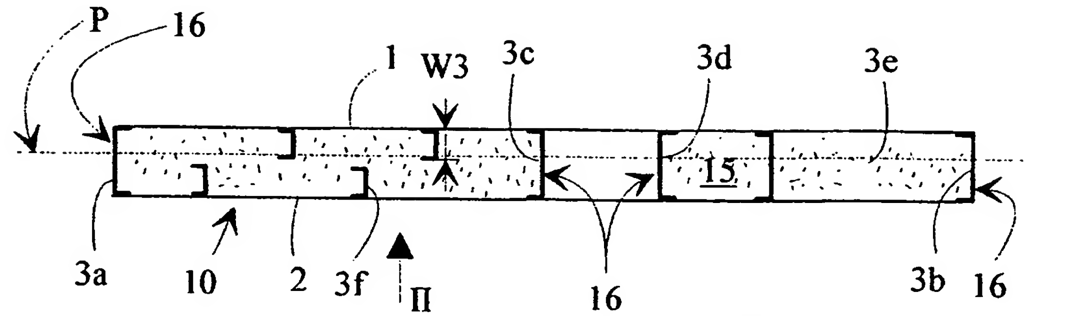

Fig. 1

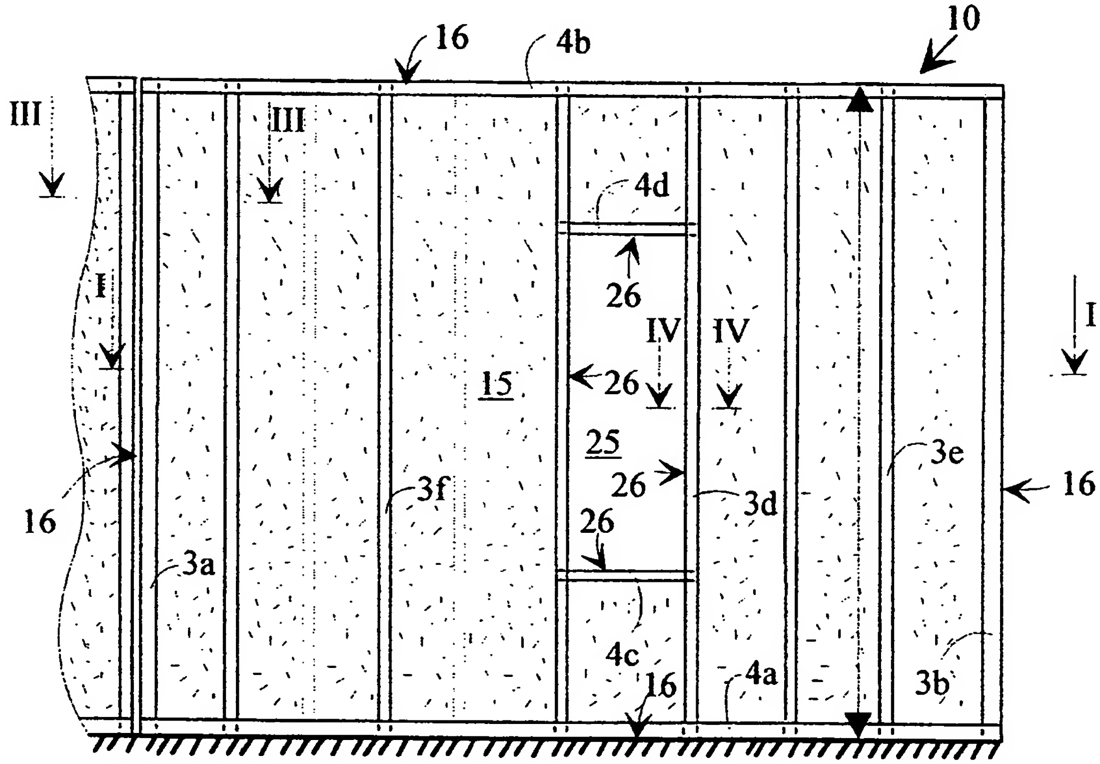

Fig. 2

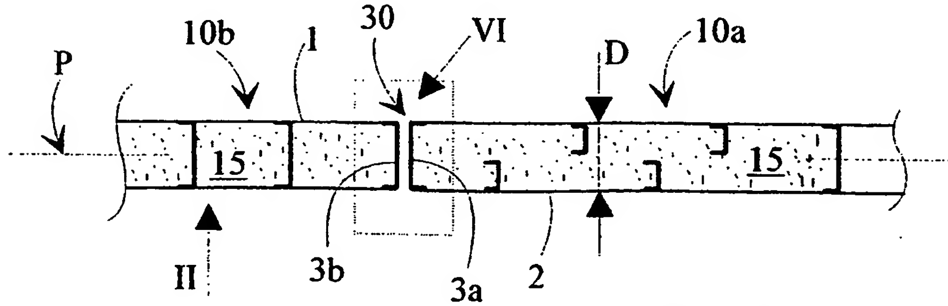

Fig. 3

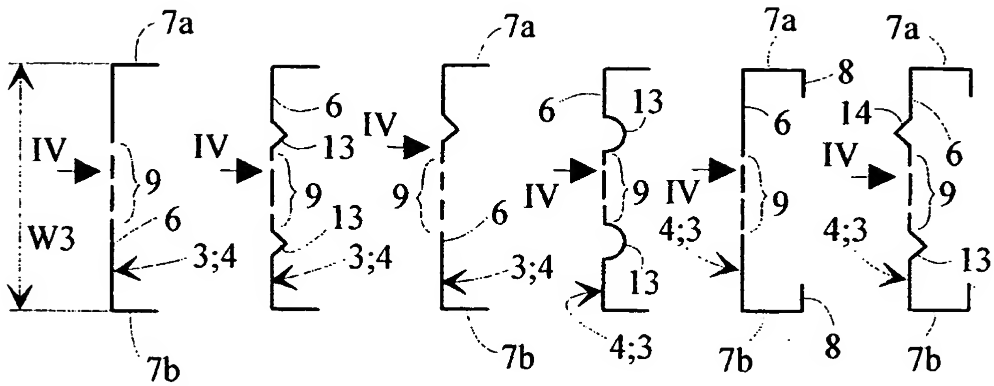

Fig. 4A Fig. 4B Fig. 4C Fig. 4D Fig. 4E Fig. 4F

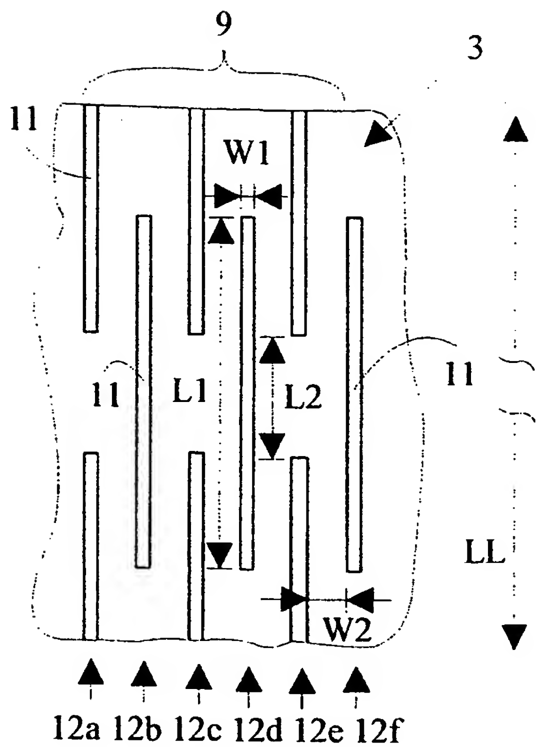

Fig. 5

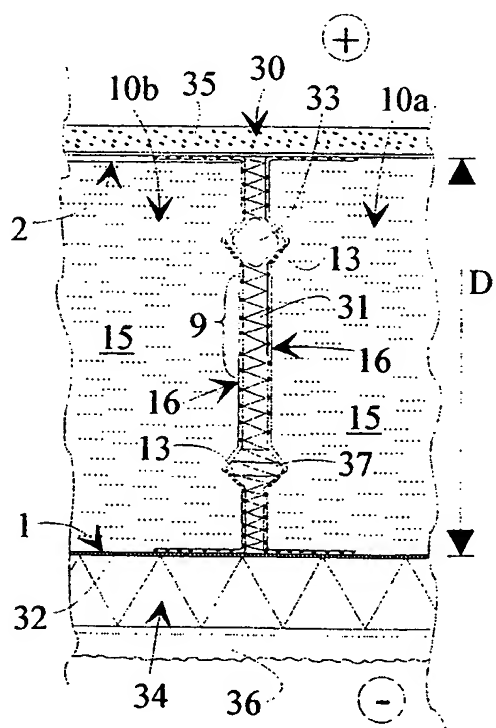

Fig.6

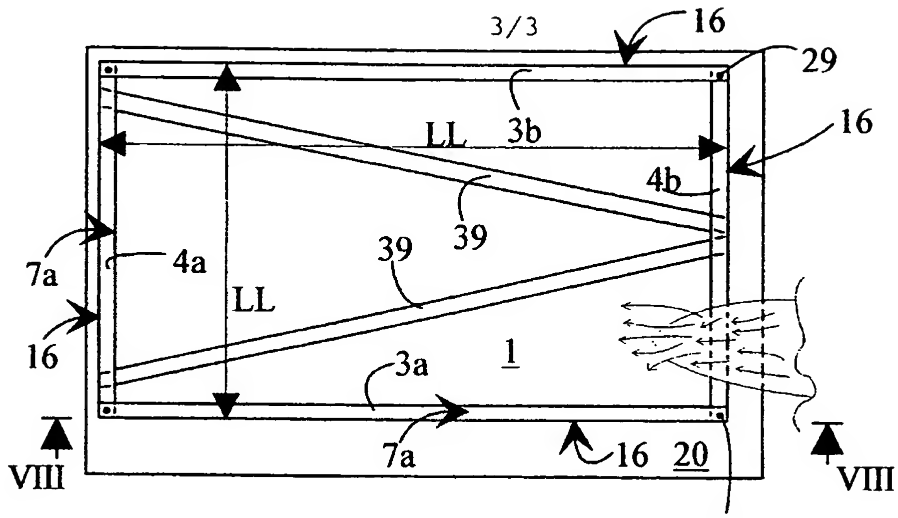

Fig. 7A

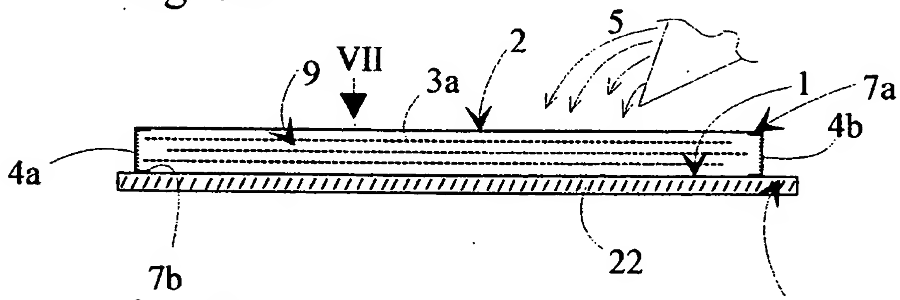

Fig. 7B

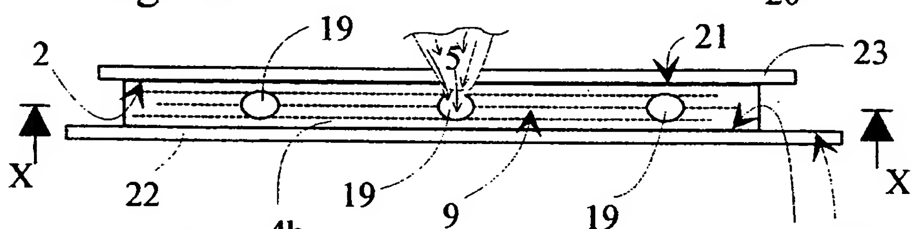

Fig. 8A

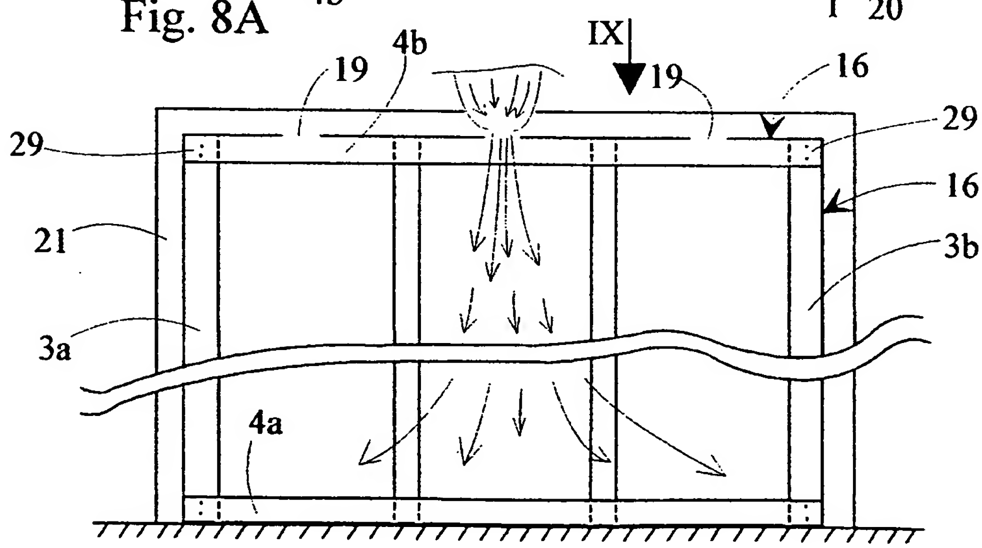

Fig. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 98/00317

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: E04B 1/80
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: E04B, E04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2762472 A (J.O. JACKSON), 11 Sept 1956 (11.09.56), column 6, line 44 - line 48, figure 1 --	1,7,8
Y	US 4638615 A (L.H. TAYLOR), 27 January 1987 (27.01.87), figure 4, abstract --	1,7,8
A	US 4713921 A (G.O. MINIALOFF ET AL), 22 December 1987 (22.12.87), figure 1, abstract --	1-13
A	US 2934934 A (H.A. BERLINER), 3 May 1960 (03.05.60), column 2, line 45 - line 49, figure 8 -- --------	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 June 1998	26 -06- 1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Vilho Juvonen Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI 98/00317

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2762472 A	11/09/56	NONE	
US 4638615 A	27/01/87	NONE	
US 4713921 A	22/12/87	NONE	
US 2934934 A	03/05/60	NONE	